Open Economy Macroeconomics

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1 The foreign exchange market

This chapter gives a first description of how the exchange rate and the foreign exchange reserves of a country are determined. We assume that the country is 'small', which in this context means just that foreign interest rates are given exogenously. The country may still be able to influence the interest rate on assets denominated in its own currency. A central topic is how far this influence goes, and what the consequences are of setting interest rates which deviate from those abroad. More details of the plan for the chapter are given towards the end of section 1.1, after we have introduced some basic concepts.

1.1 Some basic concepts

An exchange rate is the price of one currency in terms of another. In most of the chapters of this book we focus on a single country, and abstract from the fact that the rest of the world consists of many countries with different currencies. When we speak of the 'exchange rate', it is then the price of the single foreign currency in terms of the currency of the country in focus. As a shorthand we shall often refer to the foreign currency as dollars, and the domestic currency as kroner. The exchange rate is then the price of dollars in kroner.

As other prices, the price of foreign exchange is determined in a market. We can divide the participants in the foreign exchange market in two groups: the central authorities (central bank and central government) in our country on the one hand, and the general public at home and abroad on the other. (We come to the foreign central authorities later.) Normally we assume that the general public are price takers in the foreign exchange market. The trade of each is too small to have a significant influence on the price. It is different with the central authorities. Their actions in the foreign exchange market are coordinated through the central bank, and they may be large enough to influence the price of foreign exchange.

In figure 1.1 the curve depicted as S shows how the public's net supply of foreign currency depends on the exchange rate. Among the public there are some who want to sell foreign currency and some who want to buy. The net supply is the difference between the amounts that the public wants to sell and to buy. As is usual in economics, net supply is drawn as an increasing function of the price. We return to this assumption shortly.

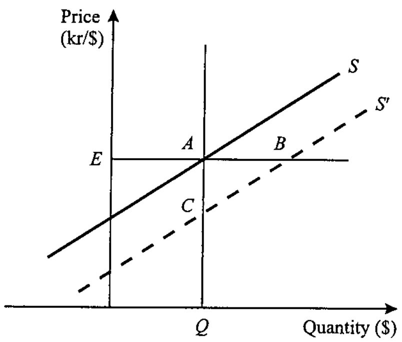

Figure 1.1 Equilibrium in the foreign exchange market.

The price that will prevail in the market depends on how much foreign currency the central bank decides to buy. If the central bank buys the quantity *Q*, the usual market forces produce an equilibrium at the intersection between supply and demand, *A*, where the price is *E*.

The units of measurement on the quantity axis need a comment. Until some years ago most theories of the foreign exchange market looked upon the supply of foreign currency as a *flow* that was to be measured in units of foreign currency per unit of time – e.g. in dollars per year. These theories tended to assume that a major part of the supply and demand for foreign currency arose from the needs of importers and exporters. The former needed foreign currency to pay for their imports, and the latter needed to convert foreign currency earnings into domestic currency which could be used to pay the domestic factors of production. Exports and imports are measured per unit of time – i.e. they are flows.

Today, however, most trade in foreign currency is *capital movements.* Foreign currency is bought and sold in order to change the composition of asset portfolios. Large stocks of wealth can be shifted from one currency to another literally in seconds. In accord with this most modern theories of the foreign exchange market look upon the supply of foreign currency as a *stock* supply. The unit of measurement for quantity is then simply units of foreign currency – e.g. dollars (not dollars per unit of time). This is the modern approach that we shall pursue. In the stock approach the supply of foreign currency at a moment in time is determined by how the public decides to invest its wealth at this moment. Thus, the supply curve in figure 1.1 is a result of decisions by (domestic and foreign) private investors on how much of their wealth they want to keep in foreign currency at this moment. When the supply curve is increasing, it means that if the price of foreign currency is higher, the investors want to have smaller net holdings of assets denominated in foreign currency, and, thus, immediately offer more foreign currency to the central bank.

The quantity Q is the net amount of foreign currency held by the central authorities. It consists of the official *foreign exchange reserve* minus the debt that the central authorities have incurred in foreign currency. For simplicity, we sometimes speak of the net amount of foreign currency assets held by the central authorities as the 'foreign exchange reserve'. When the authorities buy or sell foreign exchange, this is called *intervention*.

The central bank can pursue different strategies in the foreign exchange market. One important alternative is *fixed exchange rates*. Then the central bank sets a target exchange rate, which may be equal to E in figure 1.1. The central bank buys or sells as much foreign currency as is necessary to keep the exchange rate at E. In figure 1.1 this turns out to be the quantity Q. With fixed exchange rates, price is the exogenous policy variable, and quantity follows endogenously, determined by the supply in the market.

The opposite is *floating exchange rates*, when the quantity purchased is the exogenous policy variable, and the price follows from the market. The central bank sets Q, and E follows. The distinction between fixed and floating rates that we make here is thus a distinction according to which variable – price or quantity – the central bank uses as its decision variable.

The distinction between fixed and floating rates is sometimes described as a distinction between 'administratively determined' and 'market determined' exchange rates. This is somewhat misleading; a better analogy is a monopolistic supplier of a commodity who can use either price or quantity as her decision variable.

The difference between fixed and floating rates is not as fundamental as it may first seem. In both cases the central bank has to choose among points that are on the supply curve for foreign currency. All points on the supply curve can be reached by using either price or quantity as the decision variable. Irrespective of which variable is the decision variable, the central bank can be more or less active in the foreign exchange market. When the exchange rate is fixed, we distinguish between a *permanently fixed* rate and an *adjustable* rate. When the exchange rate is floating, we distinguish between a *clean* and a *managed* float. In the former case the central bank is supposed to be completely passive and never buy or sell foreign exchange. The quantity Q that it possesses is kept constant 'forever'. In a managed float Q is adjusted now and then. An adjustable fixed rate and a managed float may be used in such a way as to yield the same combination of Q and E. There is a greater difference between a permanent fix and a clean float.

The difference between fixed and floating rates is brought out more clearly when we look at a shift in the supply curve, as from S to S' in figure 1.1. If the exchange rate is fixed, the new equilibrium is at point B, where the price is unchanged and the foreign exchange reserves have increased. If the exchange rate is floating, the new equilibrium is at C, where reserves are unchanged and the price of foreign currency has fallen. These are the immediate consequences. If the central bank wishes, it can then adjust its policy and reach any point it wants to on the new supply curve.

When the price of foreign currency goes down, as in the example just discussed, we say that the domestic currency *appreciates*. It has increased in value relative to the foreign currency. If the price of foreign currency goes up, we say that the domestic currency *depreciates*. When the authorities change a fixed exchange rate, the corresponding terms are *revalue* and *devalue*.

Figure 1.1 gives the first example of a convention that is used throughout the book:

> *Curves that apply before a shift are drawn smooth. Curves that apply only after the shift are broken. When there is no risk of ambiguity, the curves after the shift are not labelled.*

In general, the shape and position of the supply curve depends on the public's expectations about government policy. Different exchange rate systems may entail different supply curves. The common supply curve drawn in figure 1.1 serves only to make clear the principal distinction between fixed and floating rates.

Figure 1.1 may be illustrative, but by itself it does not say much. We have to ask what is behind the supply curve: What kind of behaviour? Why does the curve slope upwards? What can cause it to shift? Section 1.2 describes an accounting framework which can be used as a basis for discussing the demand and supply of foreign currencies. Section 1.3 describes the motives behind the public's demand for different currencies. In section 1.4 we put the pieces together in a model of the equilibrium in the foreign exchange market at a moment of time. This gives us opportunity to discuss the important concept of *capital mobility* and the relationship between interest rates and exchange rates in section 1.5. There we examine to what extent it is possible for a small open economy to keep interest rates different from those abroad. Section 1.6 brings in the current account of the balance of payments. Finally, in section 1.7, we discuss the forward market for foreign exchange.

1.2 The balance sheet

For our purpose it is convenient to divide the economy into three sectors:

- Domestic government (subscript g)
- Domestic private (subscript p)
- Foreign (subscript $*$).

The domestic government sector includes the central government and the central bank. The domestic private sector comprises all other domestic sectors. For convenience, we refer to the central authorities interchangeably as the government and as the central bank, depending on which branch of policy we are discussing.

In order to keep the discussion down to the essentials, we distinguish between just two types of assets:

- Kroner assets – i.e. assets denominated in the domestic currency

Table 1.1 *Net financial assets, by sector*

	Sector			
Assets	Government	Private	Foreign	Sum
Kroner assets	B_g	B_p	B_*	0
Dollar assets	F_g	F_p	F_*	0
Sum in kr	$B_g + EF_g$	$B_p + EF_p$	$B_* + EF_*$	0

- Dollar assets – i.e. assets denominated in foreign currency.

In table 1.1 we have written down the financial balance sheet of this economy at a point in time. The new symbols are:

B_i = Net kroner assets of sector i $(i = g, p, *)$
F_i = Net dollar assets of sector i $(i = g, p, *)$

'Net assets' means assets minus liabilities. Kroner assets are measured in kroner and dollar assets in dollars.

Since we are looking at financial assets only, one agent's asset is the liability of another. If, for example, the government has borrowed 1 billion kroner from the private sector, it appears as $+1$ billion kroner in B_p and -1 billion kroner in B_g. The value of each financial asset appears with a plus sign in the accounts of one agent and a minus sign in the account of another. Thus, when we add together the net assets of all sectors in each currency, the sums must be zero:

$$B_g + B_p + B_* = 0 \tag{1.1}$$

and

$$F_g + F_p + F_* = 0 \tag{1.2}$$

Each sector's financial wealth is the sum of the net assets the sector has in different currencies. Measured in kroner the financial wealth of the different sectors is thus

$$B_i + EF_i \quad i = g, p, *$$

We shall be more interested in its real value: nominal wealth deflated by the appropriate price level. Let

P = domestic price level measured in kroner
P_* = foreign price level measured in dollars

Then the real financial wealth of the two domestic sectors is

$$W_i = \frac{B_i + EF_i}{P} \quad i = g, p \tag{1.3}$$

and that of the foreign sector is:

$$W_* = \frac{(B_*/E) + F_*}{P_*} \tag{1.4}$$

In (1.4) the numerator is foreign financial wealth measured in dollars. W_* is the same as our *foreign debt*. Note that foreign debt and debt denominated in foreign currencies are two entirely different concepts.

When measured in the same units, the net financial wealth of all sectors must of course add up to zero, as indicated in the last line of table 1.1. This means that

$$W_g + W_p + \frac{EP_*}{P} W_* = 0$$

From (1.2), it follows that the net foreign exchange holdings of the domestic government is

$$F_g = -F_* - F_p$$

or the negative of the net holdings of the two other sectors. Thus the supply of foreign currency towards the domestic central bank is the negative of the net demand for foreign currency from the other sectors. Clearly, the supply of foreign currency to the central bank will be determined by how much wealth the other sectors own, and by how they decide to distribute this between currencies.

The net financial wealth of a sector can change in two ways:

- through net investment in financial assets; if a sector's savings exceeds its investments in real capital, it has to invest the remainder in financial assets
- through revaluations – i.e. through changes in the prices of assets already held.

Saving and investment in real capital are flows with dimensions per unit of time. Only with the passage of time will the discrepancy between savings and real investment add up to sums which are significant compared to the total existing stock of assets. Thus, when we look at short time periods, as one day, or – in the extreme – one moment, we can regard the stock of financial wealth as predetermined except for the changes that occur because of revaluations.

For any period we can write down financial balance sheets at both the beginning and at the end of the period. Think of a period which is short enough for the discrepancies between saving and real investment over the period to be insignificant, and assume that all trades during the period takes place at a single price. Then the net financial wealth of each sector is the same both at the beginning and the end of the period. If we distinguish beginning-of-period stocks by an extra subscript 0, we can write

$$B_i + EF_i = B_{i0} + EF_{i0} \quad i = g, p, * \tag{1.5}$$

or

$$B_i - B_{i0} + E(F_i - F_{i0}) = 0 \quad i = g, p, *$$

Purchases of one currency have to be paid for by sales of another. Within a short period investors can redistribute their financial wealth between currencies; the total, however, is given. Its nominal value can change only with the exchange rate, its real value only with the exchange rate and the price level.

Later we use continuous time – i.e. the limiting case where the length of the market period is just one moment. Still we can think of the initial stocks as given as the moment is entered. Then the agents can redistribute their stocks momentarily.

1.3 The demand for currencies

How do private investors decide how much to invest in each currency? Obviously they will be interested in the rate of return that they achieve on their investments. Let

i = the kroner rate of interest
i_* = the dollar rate of interest
e = the rate of depreciation ($e = \dot{E}/E$, where, as usual, a dot over a variable means its derivative with respect to time)

Then the rate of return on investing in kroner is i. The kroner rate of return on investing in dollars is $i_* + e$, since in addition to the dollar interest rate the investor gets an extra return if the dollar increases in value relative to the krone. Obviously the highest return is obtained by investing in kroner if $i > i_* + e$, in dollars if $i < i_* + e$. It is easily seen that the same condition applies for someone who is interested in the dollar return. When $i < i_* + e$, it even pays to borrow kroner and invest in dollars.

However, investors cannot know what the rate of depreciation will be. Instead they have to form an opinion of how likely different rates of depreciation are.

If investors base their decisions on expected returns only, and if all investors have the same expectations, we have *perfect capital mobility* between currencies. If we denote expectations with a subscript e, the expected return from investing in kroner is i, and the expected return from investing in dollars is $i_* + e_e$. With perfect capital mobility, if $i > i_* + e_e$, everybody wants to invest all their wealth in kroner, and borrow dollars to invest even more in kroner. If $i < i_* + e_e$, they do the opposite: borrow kroner and invest in dollars. As long as $i \neq i_* + e_e$, there will be only lenders in the market for one currency, and only borrowers in the market for the other. Equilibrium in the asset markets can be achieved only if

$$i = i_* + e_e \tag{1.6}$$

When this condition holds, we have *uncovered interest rate parity*. This must always be the case when capital mobility is perfect.

Capital mobility between currencies can also be *imperfect*. This means that desired portfolios may contain both currencies in finite amounts even if uncovered interest rate parity does not hold. We can list four main reasons for this:

Exchange rate risk and risk aversion

Investors cannot know what the rate of depreciation will be. Risk averse investors are willing to forgo some expected return in order to reduce uncertainty. The way to reduce uncertainty is to divide the portfolio between the different currencies. Suppose the highest expected return is in dollars. If an investor puts all his money in dollars, he may suffer a heavy loss if the dollar depreciates more than expected. If instead he leaves some of his money in kroner, he will get a smaller expected return, but he will also suffer a smaller loss if the dollar depreciates more than expected. These arguments about risk and return are developed at length in chapter 2.

Differing expectations

As long as there is uncertainty about the future of the exchange rate, there is also room for different opinions. Some investors may expect the highest return on dollars, others on kroner. If they do not care about risk, the former group invests its wealth in dollars, the latter in kroner. The aggregate portfolio then contains both currencies. If we allow the investors to borrow, those in the first group want to borrow kroner to invest more than their total wealth in dollars. Those in the second group do the opposite. However, such borrowing will be limited because of the possibility of bankruptcy. The investors will have to borrow from people with expectations that differ from their own. If you believe for sure that kroner gives the highest return, you limit your lending to someone who bets on dollars giving the highest return. According to your belief, if the borrower has borrowed too many kroner, he is certain to go bankrupt. Endogenous credit rationing thus ensures that the net private demand for each currency is finite (positive or negative) as long as some investors believe that the highest return is in kroner and some that the highest return is in dollars.

Transaction costs and liquidity

It is costly to change money between currencies. Depending on where they trade and pay taxes, people need one or the other currency for transaction purposes. As is well known from standard discussions of the demand for money, they may then forgo some interest in order to economize on transaction costs. Even if expected returns in dollars are higher, a risk neutral investor may keep some balances in kroner in order to settle transactions that have to be made in kroner. Participating in the foreign exchange market may entail some fixed costs (e.g. costs of collecting information). These costs may keep small investors out of the market altogether.

Exchange controls

These are government regulations intended to have a direct impact on the supply of foreign currency. They may prohibit certain groups of investors from lending or borrowing foreign currency, set quantitative limits on the investments or take more subtle forms.

In this book the standard assumption is that expected return and risk are the only concerns of the investors. There are goods reasons for this focus. A large number of countries have abolished all or nearly all exchange controls. This includes all the industrialized and a large number of developing countries. As argued in chapter 2, the analysis can easily be adapted to cases where exchange controls exclude some groups from the foreign exchange market. In countries with well developed credit markets liquidity can be obtained by borrowing money. What is important in the foreign exchange market is the *net* demand for each currency. In chapter 3 we argue that this is not much affected by transaction needs when credit markets are well developed and not heavily regulated.

In the present chapter we assume more specifically that the domestic public's real demand for foreign currency is a function of its financial wealth, W_p, and the expected rate of return differential, $r = i - i_* - e_e$:

$$\frac{EF_p}{P} = f(r, W_p) \quad \text{where} \quad 0 < f_W < 1 \quad \text{and} \quad f_r < 0 \tag{1.7}$$

r is called the *risk premium* on kroner. It tells how much extra the investors get paid over the expected return on dollars to take the risk of investing in kroner. The risk premium may of course be negative.

The remainder of the public's financial wealth must be invested in kroner. Thus the demand for kroner is

$$\frac{B_p}{P} = W_p - f(r, W_p) \tag{1.8}$$

A higher risk premium in favour of kroner means that the expected return on kroner has increased relative to the expected return on dollars. Investors will then find it worthwhile to move more of their portfolios from dollars to kroner, even if this increases risk. Thus the demand for dollars depends negatively on the risk premium on kroner ($f_r < 0$), while the demand for kroner depends positively on the risk premium.

The assumption that $0 < f_W < 1$ means that if wealth increases by, say, 1 billion kroner, the public invests some of its extra wealth in kroner and some in dollars. It is not obvious that these shares should always be between zero and one. If the expected return on dollars is sufficiently higher than on kroner, investors may want to borrow kroner in order to invest more than their total financial wealth in dollars. When they get richer, they may want to borrow even more kroner in order to increase their dollar investments more than their financial wealth. The assumption that $0 < f_W < 1$ precludes this. The assumption thus limits speculative investments.

The functional form, f, must depend on the amount of uncertainty that the investors perceive, and their attitudes towards risk. We return to this subject in chapter 2.

For the foreign sector we assume similar demand functions. From their point of view kroner is the foreign currency, and their demand for kroner is in real terms

$$\frac{B_*}{EP_*} = b(r, W_*) \quad \text{where} \quad 0 < b_W < 1 \quad \text{and} \quad b_r > 0 \tag{1.9}$$

The corresponding demand function for dollar assets is

$$\frac{F_*}{P_*} = W_* - b(r, W_*) \tag{1.10}$$

Formally our demand functions are based on the assumption that all agents have the same expectations e_e. However, the demand functions may be reinterpreted in such a way that they also cover the case of differing expectations. Then we must think of e_e as the average over all investors of the expected rate of depreciation. Behind the functional form f must be the distribution of expectations around e_e among the investors. When r increases, it means that some investors tip from seeing dollars to seeing kroner as the most profitable investment – and, hence, the demand for dollars declines. However, with differing expectations we have a serious aggregation problem when there is an increase in wealth. The effect on asset demands clearly depends on whose wealth is increased: those who believe in the dollar, or those who do not. This would complicate the formal analysis, but qualitatively most of our conclusions would probably be the same.

1.4 A simple portfolio model

We now have the main elements ready to set up a simple portfolio model for the determination of the exchange rate and the foreign exchange reserves.[5] Even if this means some repetition, we rewrite all the necessary equations here. They are

$$W_p = \frac{B_{p0} + EF_{p0}}{P} \tag{1.11}$$

$$W_* = \frac{B_{*0}/E + F_{*0}}{P_*} \tag{1.12}$$

$$r = i - i_* - e_e \tag{1.13}$$

$$e_e = e_e(E) \tag{1.14}$$

$$\frac{EF_p}{P} = f(r, W_p) \tag{1.15}$$

$$\frac{F_*}{P_*} = W_* - b(r, W_*) \tag{1.16}$$

$$F_g + F_p + F_* = 0 \tag{1.17}$$

Equations (1.11) and (1.12) define financial wealth as the value of the initial stocks. Equation (1.13) defines the risk premium. Equation (1.14) just says that expected depreciation depends on today's exchange rate. We return to this shortly. Equations (1.15) and (1.16) are the two demand functions for foreign currency. Equation (1.17) is the equilibrium condition for the foreign exchange market. The net demands of all sectors added together must sum to zero.

The seven equations determine seven variables. They are W_p, W_*, F_p, F_*, r, e_e and, in the case of floating exchange rates E – or, in the case of fixed exchange rates F_g. When the exchange rate is floating, F_g is exogenous; when the exchange rate is fixed, E is exogenous. The remaining exogenous variables are P, P_*, i and i_*. In addition B_{p0}, F_{p0}, B_{*0} and F_{*0} are predetermined.

The list of exogenous variables needs some explanation. The small country assumption makes P_* and i_* exogenous. P will be endogenized in later chapters, but for the moment we look upon it as predetermined. We assume that the domestic interest rate i is set exogenously by the central bank. The central bank stands ready to lend or borrow money at this interest rate as the public demands.

We are now ready to continue the discussion of exchange rate determination from section 1.1. There we drew an upward-sloping supply curve for foreign currency. We can now examine the slope of the supply curve as it appears in the simple portfolio model. As already explained in section 1.2, the supply of foreign currency to the domestic central bank is the negative of the net demands for foreign currency by the other sectors, or

$$F_g = -F_p - F_*$$

If we insert in this first from (1.15) and (1.16), and then from (1.11)–(1.14), we get

$$\begin{aligned} F_g &= -\frac{P}{E} f(r, W_p) - P_*[W_* - b(r, W_*)] \\ &= -\frac{P}{E} f\left(i - i_* - e_e(E), \frac{B_{p0} + EF_{p0}}{P}\right) \\ &\quad - P_*\left[\frac{B_{*0}/E + F_{*0}}{P_*} - b\left(i - i_* - e_e(E), \frac{B_{*0}/E + F_{*0}}{P_*}\right)\right] \end{aligned} \tag{1.18}$$

We can see that E has two types of effects. It changes the real value of existing stocks of assets, and it changes expected depreciation. By differentiating we find that the slope of the supply curve is

$$\frac{\partial F_g}{\partial E} = \frac{1}{E}\left[F_p - f_W F_{p0} + (1 - b_W)(B_{*0}/E)\right] + \left[(P/E)f_r - P_* b_r\right] e_e'$$

As is standard practice in portfolio models, we compute the derivative at the initial equilibrium – i.e. where $F_p = F_{p0}$ and $B_* = B_{*0}$. The expression can then be simplified to

$$\frac{\partial F_g}{\partial E} = \frac{P}{E^2}\gamma - \frac{P}{E}\kappa e_e' \tag{1.19}$$

where

$$\gamma = (1 - f_W)\frac{EF_{p0}}{P} + (1 - b_W)\frac{B_{*0}}{P}, \quad \text{and} \quad \kappa = -f_r + \frac{EP_*}{P} b_r > 0$$

Thus the effect of the exchange rate on the supply of foreign currency can be split into two main components:

- *The portfolio composition effect* measured by γ. When the domestic currency is depreciated, all foreign currency assets increase in value relative to domestic currency assets. This changes both the wealth distribution between sectors and the value distribution of each sector's portfolio on the two currencies. As a result investors will rebalance their portfolios, and this is the portfolio composition effect.
- *The expectations effect*, measured by $-\kappa e_e'$. A depreciation may change expectations about future depreciation. This changes the risk premium, which again changes the demand for foreign currency. How strongly the real demand for foreign currency reacts to the risk premium is measured by κ.

It is not obvious that $\partial F_g/\partial E$ is positive. Consider first the portfolio composition effect. If the domestic public has positive net foreign currency assets ($F_{p0} > 0$), it is made richer by a depreciation. If $0 < f_W < 1$, it wants to invest some of its increased wealth in foreign currency, and some in kroner. However, the immediate effect of the depreciation is to increase the value of the foreign currency the private sector already possesses by the same amount as the increase in wealth. After the depreciation, the public then wants to reduce its holdings of foreign currency and buy kroner. Thus, if both $F_{p0} > 0$ and $f_W < 1$, the wealth effect means that a depreciation lowers the domestic public's demand for foreign currency. This contributes through the first term in (1.19) to a positive slope of the supply curve. It will contribute to a negative slope if either assumption is violated – i.e. if the public has foreign currency debts ($F_{p0} < 0$) or if there is excessive speculation ($f_W > 1$).

A symmetric statement can be made about the portfolio composition effect on foreigners. If foreigners have positive holdings of our currency ($B_{*0} > 0$), they *lose* from a depreciation. If $0 < b_W < 1$, they want to spread the reduction in wealth on kroner and dollar assets. However, the immediate effect of the depreciation is to reduce the value of the kroner assets they already possess by the same amount as the reduction in wealth. After the depreciation, the foreigners then want to reduce their holdings of foreign currency and buy kroner. Thus, if both $B_{*0} > 0$ and $b_W < 1$, the portfolio composition effect means that a depreciation lowers the foreign public's demand for foreign currency, and this contributes to a positive slope of the supply curve (cf. (1.19)).

Another way of looking at the portfolio composition effects is: suppose the public at home and abroad hold positive amounts of both currencies. A depreciation of the domestic currency means that the value share of domestic currency in all portfolios decreases. When $0 < f_W < 1$ and $0 < b_W < 1$, the public responds to this by selling some foreign currency to increase the share of kroner again. In this way, they keep the portfolio diversified and hedge against further changes in the exchange rate in one direction or the other.

Now to the expectations effect in (1.19). Its sign clearly depends on the sign of e_e'. We can define three cases:

- *Regressive expectations*, $e_e' < 0$. A depreciation now lowers the expected future depreciation.
- *Extrapolative expectations*, $e_e' > 0$. A depreciation now increases expected future depreciation.
- *Constant expectations*, $e_e' = 0$. A depreciation now has no effect on expected future depreciation.

Only in the case of regressive expectations is the expectations effect in (1.19) positive. If expectations are regressive, a depreciation of kroner now leads to a decrease in the expected future return on dollars. The private investors then move some of their portfolio from dollars to kroner, and thus offer more dollars to the central bank.

There is no general answer to whether expectations are regressive or extrapolative. An often used example of an e_e function is

$$e_e = \alpha \frac{E_e - E}{E} \tag{1.20}$$

where E_e is an expected future equilibrium exchange rate and the constant α is the expected speed of convergence towards the equilibrium. If E_e is independent of E, expectations in this example are regressive ($e_e' = -\alpha E_e / E^2 < 0$). More generally, if the expected future *level* of the exchange rate is independent of the present level, this tends to make expectations regressive. The reason is that the higher the present exchange rate, the more the exchange rate must fall from today's level in order to reach the expected future level. A depreciation beyond the expected future level now, implies an expected future appreciation. As (1.20) reveals, it is sufficient for this argument that E_e depends less than proportionally on E. For the period of floating surveys of exchange rate expectations have produced some evidence that they tend to be regressive when the horizon is not too short (see Takagi, 1991).

In a fixed rate system a devaluation usually changes the expected future exchange rate. Suppose, however, that e_e were positive before the devaluation. Immediately after the devaluation there is often little reason to expect another. Thus, e_e may become equal to zero after the devaluation. An increase in E has then led to a fall in e_e, as with regressive expectations. However, the devaluation may make people think that the government has become more prone to devalue. If that is the case, expected depreciation may soon rise again.

Expectations are a subjective entity, but they should depend on the factors which determine the future exchange rate. The slope of the supply curve may depend on government policy giving people reason to have regressive expectations. In chapter 4, we present more sophisticated models of expected depreciation where the e_e function is derived, not postulated.

Our discussion of the slope of the supply curve can be summarized like this: a set of sufficient conditions for the supply curve to be increasing is

$$F_{p0} > 0, \quad B_{*0} > 0, \quad f_W < 1, \quad b_W < 1, \quad e_e' < 0 \tag{1.21}$$

These conditions can sometimes be violated. The public at home or abroad may have net debts in the other currency. There may be excessive speculation. Expectations may be extrapolative. Even if one condition is violated, the total effect of a depreciation may still be positive. However, we cannot exclude *a priori* that the supply curve slopes downwards. In some countries the private sector has borrowed heavily in foreign currencies, and large deviations from interest rate parity may lead to excessive speculation.

If the supply curve is falling, the foreign exchange market is unstable. Fixed exchange rates, or some degree of exchange rate management, must then be preferred in order to avoid chaos in the market.

Since the slope of the supply curve is in general not decided, it is also possible that the supply curve is bending several times, as in figure 1.2. Then we have multiple equilibria with floating rates. In figure 1.2 there are three of them, two stable (A and C) and one unstable (B).

In the sequel we assume that the supply curve slopes upwards everywhere, and that there is thus just one equilibrium. This case completely dominates the literature. Then exchange rates and reserves are determined as described in section 1.1. We have just given a somewhat deeper explanation for the supply curve, and learned more about

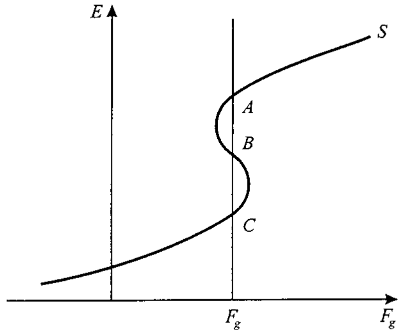

Figure 1.2 Multiple equilibria.

variables which can shift it. In section 1.5 we take a closer look at the effects of interest rates and of exchange rate expectations, and discuss the consequences of deviating from uncovered interest rate parity. Before that, however, there are two matters which deserve comment: the kroner market and the foreign central bank.

The market for kroner is a mirror image of the market for foreign currency. When one is in equilibrium, the other must also be in equilibrium. Corresponding to the supply of foreign currency there is a demand for kroner from the domestic central bank, which is given by

$$\begin{aligned} -B_g &= B_p + B_* \\ &= P\left[W_p - f(r, W_p)\right] + EP_* b(r, W_*) \end{aligned} \tag{1.18a}$$

If we differentiate this with respect to E, we find that when conditions (1.21) are satisfied, the demand curve slopes upwards, as in the right-hand panel of figure 1.3. When the exchange rate is depreciated, the public supply more dollars to the central bank. As a mirror image of that, they demand more kroner from the central bank. The fact that the demand curve for kroner slopes upwards is not so surprising when we remember that E is the inverse of the price of kroner. The central bank's net supply of kroner is $-B_g$, the net amount of kroner that it borrows from the public (or, if you prefer, the net kroner claims that the public has on the central bank).

Equation (1.18a) can also be interpreted as the equilibrium condition for the kroner market. It is equivalent to the equilibrium condition for the foreign exchange market (1.18). Just insert in (1.18a) for B_g and B_* from the balance equations (1.4), and use the definitional equations from section 1.2 a couple of times, and you have (1.18). This shows that when the foreign exchange market is in equilibrium, the kroner market is also in equilibrium. We here see an example of Walras' law: when there are n markets and $n-1$ of them are in equilibrium, the nth market must also be in equilibrium.

In figure 1.3 we have illustrated how a positive shift in the supply of foreign currency affects the two markets. We may think of the shift as caused by a rise in the kroner interest rate. The public moves some of its portfolio from dollars to kroner. This means that they demand more kroner from the central bank – i.e. they increase their kroner deposits or reduce their borrowing of kroner from the central bank. Corresponding to

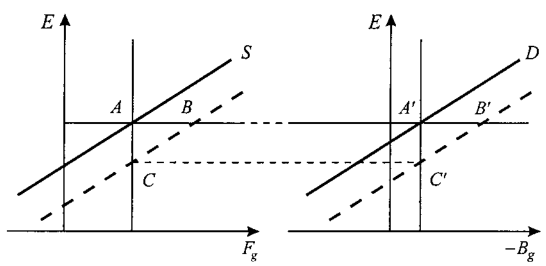

Figure 1.3 The relationship between the markets for foreign currency and for kroner.

the increased supply of foreign currency there is an increased demand for kroner of the same amount. If the exchange rate is fixed, the central bank's net kroner debt increases by the same amount as the foreign exchange reserves increases – i.e. the equilibrium moves from A and A' to B and B'. If the exchange rate is floating and the central bank does not intervene in the foreign exchange market, both its net kroner and its net dollar assets are constant. The new equilibrium is where the new supply and demand curves intersect with the vertical lines marking the given quantities (points C and C'). Whether we look at the kroner market or the foreign exchange market, the new equilibrium exchange rate is the same, since the equilibrium conditions are equivalent.

Now to the foreign central bank. An exchange rate is a relative price between two currencies (or between one currency and a basket of other currencies). In a world with two currencies there must be two central banks, but there can be only one exchange rate. Clearly, both countries cannot fix the exchange rate independently. When we have discussed fixed exchange rates, we have so far assumed that the exchange rate is set unilaterally by the domestic central bank, and that the domestic central bank alone undertakes to intervene in the foreign exchange market. This assumption is retained until chapter 9, where we discuss different ways of organizing the international monetary system and of dividing responsibilities between countries.

1.5 Capital mobility, interest rates and expectations

Suppose there is an increase in the domestic interest rate. This will lead investors to sell some dollars and invest more of their wealth in kroner. Thus, the supply curve for dollars shifts to the right. As we saw in figure 1.1, this leads to an increase in the foreign exchange reserves if the exchange rate is fixed, and to an appreciation if it is floating. The same obviously happens if there is a fall in the foreign interest rate, or if there is an exogenous reduction in the expected rate of depreciation.

From (1.18), the effect of the interest rate on the supply of foreign currency is

$$\frac{\partial F_g}{\partial i} = -\frac{P}{E} f_r + P_* b_r = \frac{P}{E}\left[-f_r + \frac{EP_*}{P} b_r\right] = \frac{P}{E}\kappa > 0 \tag{1.22}$$

$\kappa = -f_r + (EP_*/P)b_r$, which we already encountered in section 1.4, is a measure of the *degree of capital mobility* between the two currencies. A high degree of capital mobility means that differences in expected return have a strong effect on the supply of foreign currency. Generally we expect the degree of capital mobility to be high if investors have little risk aversion, or if there is not much exchange rate risk; this is explained in chapter 2.

In the present section we look at the consequences for the foreign exchange market and for interest rate policy of different degrees of capital mobility. What does the degree of capital mobility mean for the effects of interest rates, expectations and central bank interventions? To what extent does high capital mobility restrict the options the central bank has when setting interest rates? Throughout we assume that expectations are regressive ($e_e' < 0$) and that the portfolio composition effect has the usual sign ($\gamma > 0$).

Floating exchange rates

We have already seen that the slope of the supply curve for foreign currency, (1.19), depends on κ. A high degree of capital mobility means a flat supply curve (high $\partial F_g/\partial E$). An immediate effect of this is that a purchase of a given amount of foreign currency by the central bank has a small effect on the exchange rate. Thus, interventions lose some of their effect when capital mobility is high. Algebraically we find the effect of F_g on E by differentiating the equilibrium condition (1.18) with respect to these two variables. This yields

$$dF_g = \frac{\partial F_g}{\partial E}\, dE$$

or

$$\frac{dE}{dF_g} = \frac{1}{\frac{\partial F_g}{\partial E}} = \frac{1}{(P/E^2)\gamma - (P/E)\kappa e_e'} > 0 \tag{1.23}$$

(cf. (1.19)). We recognize the portfolio composition effect and the expectations effect in the denominator. When the central bank buys foreign currency, it drives up the price. As the price increases, investors sell foreign currency, partly because they rebalance their portfolios and partly because they expect the price of foreign currency to increase less in the future. In this way, equilibrium is restored at a higher E. The more investors are willing to sell when the price goes up, the smaller the price increase. From (1.23) we can see that dE/dF_g declines with an increase in κ. The reason is that when expectations are regressive, high capital mobility means that investors react to a small price increase by selling large amounts of foreign currency. Obviously, strongly regressive expectations (a high $|e_e'|$) reduce the effect of an intervention on today's exchange rate in the same way as high capital mobility does.

With perfect capital mobility the simple portfolio model of section 1.4 collapses, because we do not have separate demand functions for each currency. Instead, the exchange rate is determined by the interest parity condition $i = i_* + e_e(E)$, which in this case becomes the equilibrium condition for the foreign exchange market. This means that the supply curve for foreign currency in figure 1.1 is horizontal at the exchange rate determined by the interest parity condition: F_g has no effect on E. The same happens, of course, when κ goes to infinity. The supply curve defined by (1.18) becomes horizontal, and interventions cease to have an effect on E. In (1.23) dE/dF_g approaches zero.

The effect on E of an increase in i depends on κ for two reasons. First, the direct impact of an increase in i on the supply of foreign currency is by definition greater when capital mobility is high. Second, the supply curve is flatter when capital mobility

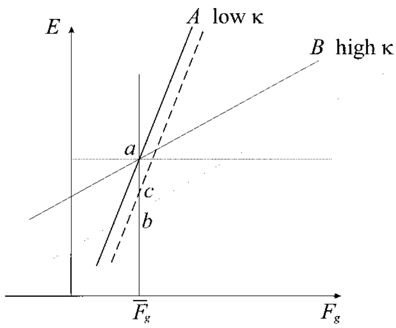

Figure 1.4 The effect on E of an increase in i for different degrees of capital mobility.

is high. This is illustrated in figure 1.4 where the curve marked B represents higher capital mobility than A. The initial equilibrium is at a. With high capital mobility an increase in i results in a large rightward shift of the supply curve. However, because of the different slopes of the curves, it is not immediately obvious in which case the effect on E is strongest. It is thus not obvious whether the new equilibrium with high capital mobility b, is above or below the new equilibrium with low capital mobility, c. Here it is helpful to differentiate the equilibrium condition (1.18) in order to find the derivative of E with respect to i. This yields

$$dF_g = \frac{\partial F_g}{\partial E} dE + \frac{\partial F_g}{\partial i} di = 0$$

or (cf. (1.19) and (1.22)):

$$\frac{dE}{di} = -\frac{\frac{\partial F_g}{\partial i}}{\frac{\partial F_g}{\partial E}} = -\frac{\kappa}{\gamma/E - \kappa e_e'} = -\frac{1}{\gamma/(\kappa E) - e_e'} < 0 \tag{1.24}$$

The denominator is positive whenever the supply curve slopes upward.

The absolute value of dE/di is increasing in the degree of capital mobility. Thus, the interest rate has a stronger effect on the exchange rate when capital mobility is high, as figure 1.4 also illustrates. When κ goes to infinity, the effect of the interest rate on the exchange rate goes to $1/e_e'$. This is, of course, the same effect as we get by differentiating the equilibrium condition under perfect capital mobility, $i = i_* + e_e(E)$. Thus, when expectations are regressive, there is an upper limit to the effect of the interest rate on the exchange rate.

The higher the level of $|e_e'|$, the smaller the effect of the interest rate on the exchange rate according to (1.24). If, on the contrary, $|e_e'|$ is close to zero while capital mobility is high, the exchange rate becomes very sensitive to interest rates. The market is then close to being unstable in the sense discussed in section 1.4. Shifts in the expected rate of depreciation work in the same way as changes in interest rates. Thus, they too have greater effect on E when capital mobility is high.

The importance of exchange rate expectations can be illustrated with an example. Interpret the model as a period model. Let E_e be the exchange rate expected to prevail next period. Then the expected rate of depreciation from this period to the next is

$$e_e = \frac{E_e - E}{E} \tag{1.25}$$

Obviously, these expectations are regressive when E_e is constant. Assume first perfect capital mobility. Insert (1.25) in the interest rate parity condition and solve for the equilibrium exchange rate. You then get

$$E = \frac{E_e}{1 + i - i_*}$$

Thus, this period's exchange rate is proportional to the exchange rate expected for next period. The factor of proportionality depends on the interest rate differential $i - i_*$. If interest rates are close to each other, the deviation from the expected exchange rate for next period will be small. If the domestic interest rate is above the foreign interest rate, we must have an expected depreciation, and this requires that E is lower than E_e.

Suppose the exchange rate one year from now is expected to be 100, and this is not affected by today's interest rates. Then if $i = i_*$ and capital mobility is perfect, the formula above tells us that the exchange rate today will also be 100. If we raise the domestic one-year interest rate 1 per cent above the foreign rate, today's exchange rate will be 99. If we make the differential 10 per cent, today's exchange rate will be 91. It is not uncommon that a floating exchange rate moves by more than 10 per cent in a few weeks. Small changes in interest rates will not stop such movements unless investors revise their expectations of exchange rates one year ahead. Thus, compared to expectations interest rates may seem relatively unimportant.

If capital mobility is imperfect, the effects of interest rates are even smaller. However, the effect of E_e is also less than proportional.[6]

The above discussion assumes that the function $e_e(E)$ is independent of current policies as represented by F_g and i. However, if current policies give signals about future policies, they may affect expected future exchange rates directly and hence shift the e_e function. Such signalling effects come in addition to the more direct effects discussed above. Dominguez and Frankel (1993a) analyse a number of cases where interventions have been used in attempts to influence the exchange rates between the major currencies (yen, mark, dollars) after they became floating in the early 1970s. The evidence that they had much direct effect seems weak. This is consistent with the view that capital mobility was high. However, the authors claim that in some instances the interventions had important signalling effects. One explanation may be that they gave signals about future interest rates and, hence, affected expected future exchange rates that way. Be that as it may, it is obviously important to examine how investors can form rational expectations about future exchange rates. This topic is best treated after we have gained some understanding of the effects of exchange rates on the real economy and on inflation.

Fixed exchange rates

As we already know, the supply of foreign currency to the central bank is an increasing function of the risk premium, r. When the exchange rate is fixed, the foreign exchange reserve is then also an increasing function of the risk premium. Two examples are shown in figure 1.5, where the steeper curve corresponds to the lower degree of capital mobility. When κ goes to infinity, the 'supply curve' in figure 1.5 approaches a horizontal line. Presumably this is located at $r = 0$, which means that as κ goes to infinity, the economy approaches perfect capital mobility.

The central bank can choose the size of the risk premium by varying the interest rate. However, it has to accept the ensuing changes in the level of reserves. These can be large if capital mobility is high. If the central bank sets the interest rate too low, it risks running out of reserves. In principle it can then borrow foreign currency in order to satisfy the demands of the other sectors. However, there will be limits to how much the central bank (or its government) can borrow, especially in the very short run. Thus there may be a lower limit for the interest rate below which the central bank is unable to accommodate the ensuing demand for foreign currency.

Even if the central bank does not run out of reserves, it may be costly to set interest rates which deviate from interest rate parity. The reason is that if the interest rate differential is large, the central bank inevitably ends up as borrower in the market with high expected returns, and as lender in the market with low expected returns. Let p be the domestic rate of inflation ($p = \dot{P}/P$). Then, the real return on the central bank's portfolio is

$$(i - p)B_g + (i_* + e - p)EF_g$$

From (1.5) $EF_g = B_{g0} + EF_{g0} - B_g$. By inserting this we find that the real return is

$$(i_* + e - p)(B_{g0} + EF_{g0}) + (i - i_* - e)B_g$$

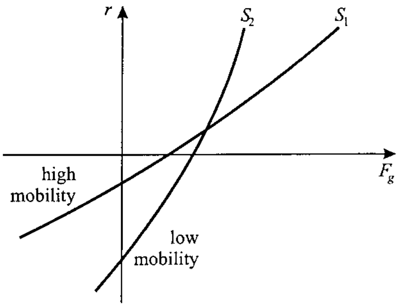

Figure 1.5 Risk premium and reserves.